# Land

## *Our Changing Earth*

NASA's Earth Observing System scientists study the Earth as a system in order to be able to predict change. All aspects of the system are actively interlinked. For example, exchanges of energy and moisture, and chemicals such as carbon dioxide, methane, nitrogen oxides, and hydrocarbons take place between the vegetation and the atmosphere. These exchanges are influenced by properties of the land, such as the underlying soils, the overlying vegetation, and land management practices, so understanding land cover changes helps us to understand the whole Earth system. Building a global picture of changes on the land, the Earth Observing System provides data on vegetation patterns; desertification; deforestation; the occurrence of fires, floods, and volcanoes; and more.

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NW-2002-2-029-GSFC

**The Earth Science Enterprise**
**The Earth Observing System**
*eos.nasa.gov*

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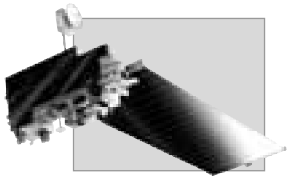
# Our Changing Earth—A Mission Sampler



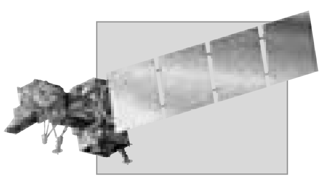
## Terra Mission

The Terra mission, launched in December 1999, carries five instruments, three of which provide significant contributions to land studies: the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), the Multi-angle Imaging Spectroradiometer (MISR), and the Moderate Resolution Imaging Spectroradiometer (MODIS).

ASTER obtains high-resolution image data over targeted areas of the Earth's surface, as well as black-and-white stereo images. Every 4 to 16 days, it provides repeat coverage of changing areas on the Earth's surface. ASTER data will be used by Earth scientists to address a wide range of global-change and natural hazard topics including volcanoes and glaciology.

MISR measures the amount of sunlight that is scattered in different directions under natural conditions, using nine cameras mounted at different angles. As the instrument flies overhead, the Earth's surface is successively imaged by all nine cameras. Scientists are using MISR data to develop new methods for mapping vegetation cover based on the vertical structure of plants.

MODIS provides a comprehensive series of global observations every two days at spatial resolutions up to 250 meters (820.2 feet). Scientists can now provide global maps to ascertain changes in vegetation type, extent and productivity. MODIS can also be used to monitor the extent of frost or drought damage to croplands over large areas. Such maps are also needed to determine the overall health and status of agricultural crops throughout the growing season. This information is vital for monitoring the world's food resources.



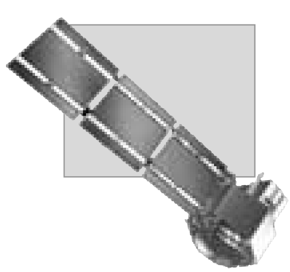
## Landsat 7 Mission

Landsat 7 is the latest in a series of satellites that have provided a continuous set of essential land surface data to both national and international users since 1972. The Landsat 7 system collects and archives an unprecedented quantity of high-quality multispectral data each day, enabling us to monitor agricultural productivity, urban growth, and land-cover change, as well as volcanoes, glacier dynamics, and coastal conditions, and providing data needed for oil, gas, and mineral exploration. While NASA's other EOS instruments MODIS and MISR acquire frequent, coarse views of land-cover change, the spatial resolution of data from the Enhanced Thematic Mapper Plus (ETM+) instrument on Landsat 7 allows researchers to determine the actual causes of observed land cover changes. These changes have important implications both for local habitability and the global cycling of carbon, nitrogen, and water.

## Shuttle Radar Topography Mission (SRTM)

The SRTM payload onboard the Space Shuttle Endeavour launched into space on February 11, 2000 for a 10 day mission to map the Earth's land surface. With its radars sweeping most of the land surfaces of the Earth, SRTM acquired a near-global high-resolution database of the Earth's topography.

SRTM is an international project spearheaded by the National Imagery and Mapping Agency (NIMA) and NASA with collaboration by the German and Italian Space Agencies. The artist's rendering at the left depicts the Space Shuttle Endeavour and the SRTM mast. Inside the Endeavor payload bay was a dual frequency radar system. The mast was 60 meters (200 feet) long and supported a second set of radar antennae which made topography measurements from radar interferommetry possible.



## EO-1 Mission

Earth Observing-1 (EO-1) is the first satellite in NASA's New Millennium Program Earth Observing series. EO-1's primary focus is to develop and test a set of advanced technology land imaging instruments; however, many other key instruments and technologies are part of the mission. EO-1 will have wide ranging applications to future land imaging missions in particular, and future satellites in general. EO-1 is flying in formation with the Landsat 7 satellite taking a series of the same images. Comparison of these "paired scene" images will be one means to evaluate EO-1's land imaging instruments.

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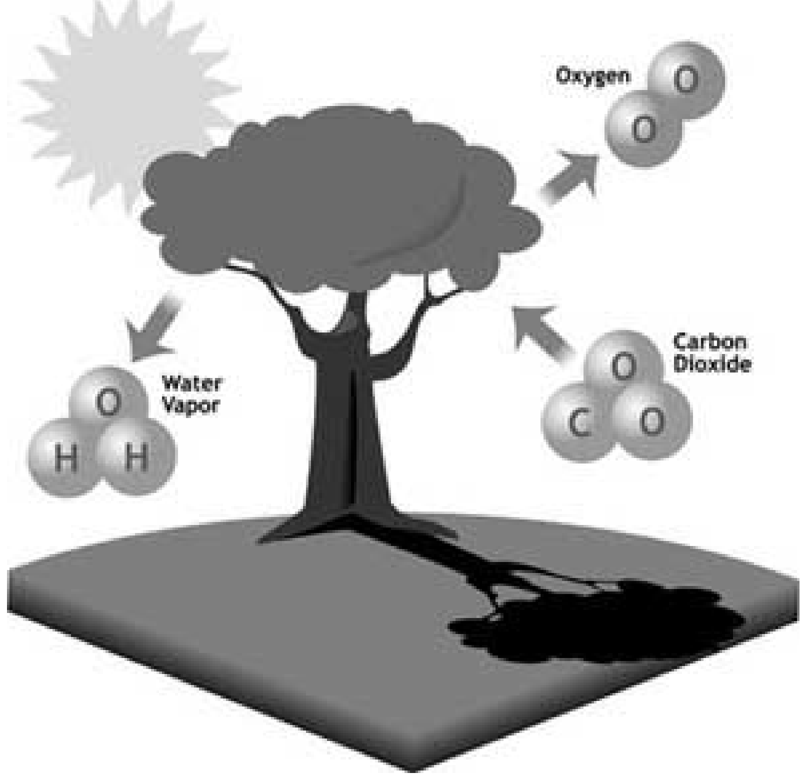
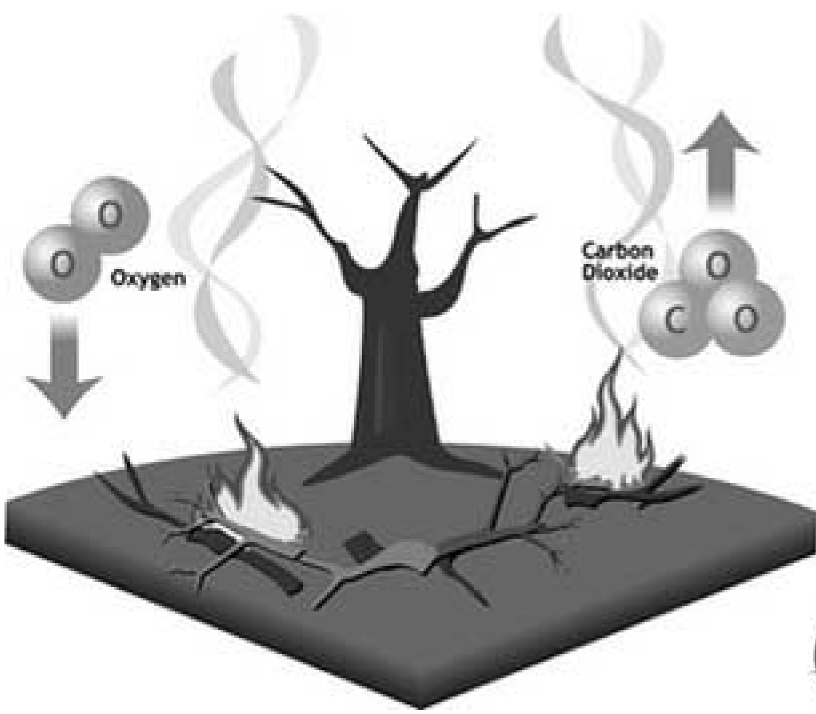
# Natural $CO_2$ Cycle

Carbon is key to life, and it moves throughout the Earth system in a major biogeochemical cycle. Photosynthesis by land plants plays an important role in that cycle. As seen in the illustration on the right, carbon dioxide from the surrounding air is absorbed by the tree and converted to oxygen, which is then released back into the air during photosynthesis. This process results in a net removal of carbon dioxide from the air and its storage in the tissues of plants. In this way, carbon moves from one sphere of the Earth system (the air) to another (the land), where it is temporarily stored. (Dry wood is about 50% carbon.)




# Biomass Burning and $CO_2$




When forests die and decay or are burned, large amounts of plant tissue, known as biomass, are oxidized, and carbon dioxide returns to the air. The burning of tropical forests has increased dramatically in recent decades and currently releases about 10 to 20% as much carbon dioxide into the atmosphere as the burning of fossil fuels. The effects of that increase in carbon dioxide ripple throughout the Earth system, and monitoring these changes by satellite is essential.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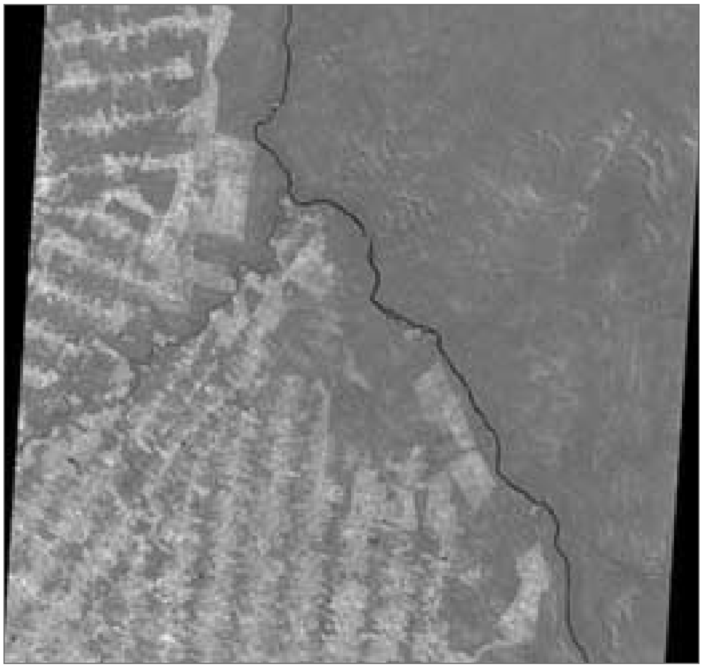
# Views of Deforestation



The image at the left, acquired by ASTER on August 24, 2000, shows the extent of deforestation in the state of Rondonia, Brazil. Tropical rainforest appears dark gray and cleared land appears light gray.

The Amazon Basin is the largest continuous region of tropical forest in the world, containing nearly 31% of the world's total. Monitoring global deforestation here provides critical information on the Earth as a system, as plant cover interacts with the air, soil, and water in many ways.

Deforestation increases the amount of carbon dioxide and other trace gases in the atmosphere, as the plants are burned or decomposed, and the chemicals in them are transferred to the atmosphere. Deforestation has other important effects. It reduces the evaporative cooling that takes place from plants, and exposes soil to erosion. Though they occupy less than 7% of the terrestrial surface, tropical forests provide homes to half or more of all plant and animal species. When tropical rainforest habitats are lost, great numbers of species become extinct.

*Image credit: NASA/GSFC, METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team*

The image to the right, acquired from Landsat 7 on August 1, 2000, shows how a large agricultural development effort, called the Tierras Baja project, and resettlement of people from the Andean high plains have brought rapid deforestation of the tropical dry forest in Santa Cruz de la Sierra, Bolivia. The radial patterned fields are part of the San Javier resettlement scheme. At the center of each unit is a small community including a church, school, and soccer field. The rectilinear, light-colored areas (right section of image) are fields of soybeans, cultivated for export. The dark strips running through these fields are wind breaks. These are advantageous because the soils in this area are fine and prone to wind erosion. Though forest has been lost, the creation of wind breaks and other resource management strategies can improve the health of the ecosystem.

*Image credit: U.S. Geological Survey EROS Data Center and Landsat 7 Science Team*

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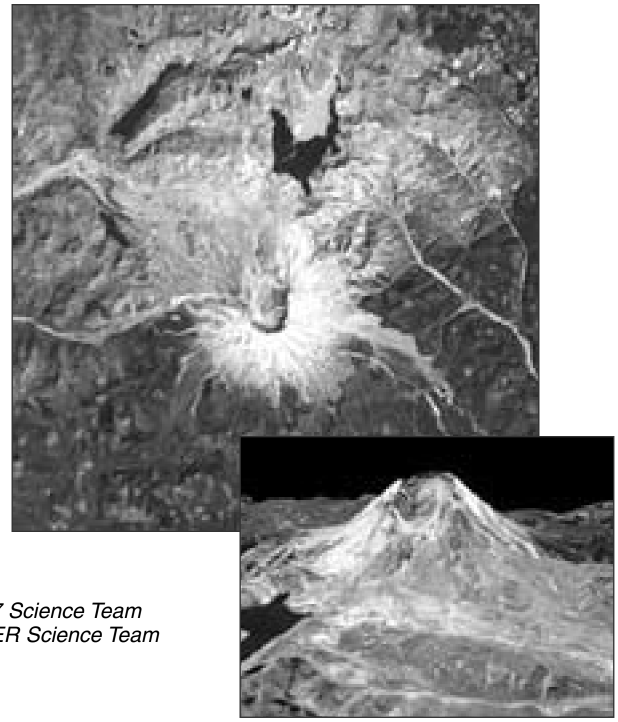
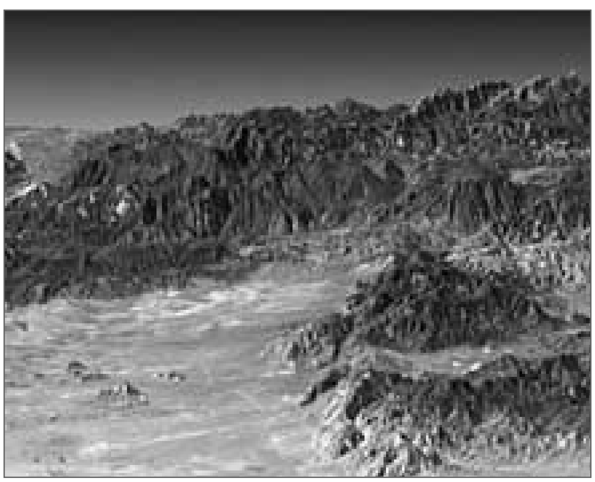
# Mount St. Helens

Vegetation on Mount St. Helens is actively recovering from the massive eruption on May 18, 1980, as seen in the image at right with inset. Landsat 7 acquired the larger image on August 22, 1999. Some of the effects of the eruption can still be seen clearly, especially on the northern and eastern flanks of the mountain, which are still mostly barren (shades of white and light gray). The crater is in the center of the image. Note the streaking from the crater (gray on the image). These are the remnants of superheated avalanches of gas, ash and pieces of rock (called pyroclastic flows) that carved deep channels down the slopes and onto the relatively flat areas near the base of the mountain. As a result of the eruption, the mountain's elevation decreased from 2,950 meters (9,678 feet) to 2,549 meters (8,363 feet). Partially-filled Spirit Lake can be seen just to the northeast of the crater, and the location where most of the energy was directed during the blast is the gray area immediately to the northwest of the crater. However, on other parts of the mountain, revegetation proceeds. Ash deposits have supplied minerals to the soil and accelerated vegetation growth.



The inset image was acquired by ASTER on August 8, 2000 and covers an area of 37 by 51 kilometers (about 23 by 32 miles). Topography has been exaggerated 2 times to enhance the appearance of the relief.

*Landsat 7 image credit: U.S. Geological Survey EROS Data Center and Landsat 7 Science Team*
*ASTER image credit: NASA/GSFC, METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team*



# The Mojave Desert

Southern California's dramatic topography plays a critical role in its climate, hydrology, ecology, agriculture, and habitability. This image of Southern California, from the desert at Mojave to the ocean at Ventura, shows a variety of landscapes and environments. Winds usually bring moisture to this area from the west, moving from the ocean across to the coastal plains, to the mountains, and then to the deserts. Most rainfall occurs as the air masses rise over the mountains and cool with altitude. Continuing east, and now drained of their moisture, the air masses drop in altitude and warm as they spread across the desert. The mountain rainfall supports forest and chaparral vegetation, seen here, and also becomes ground water and stream flow that supports citrus, avocado, strawberry, other crops, and a large and growing population on the coastal plains.

This perspective view was generated by draping a Landsat satellite image over a preliminary topographic map, acquired by the Shuttle Radar Topography Mission (SRTM) aboard the Space Shuttle Endeavour in February 2000. It shows the Tehachapi Mountains in the right foreground, the city of Ventura on the coast at the distant left, and the easternmost Santa Ynez Mountains forming the skyline at the distant right.

*Image credit: NASA/JPL, National Imagery and Mapping Agency*

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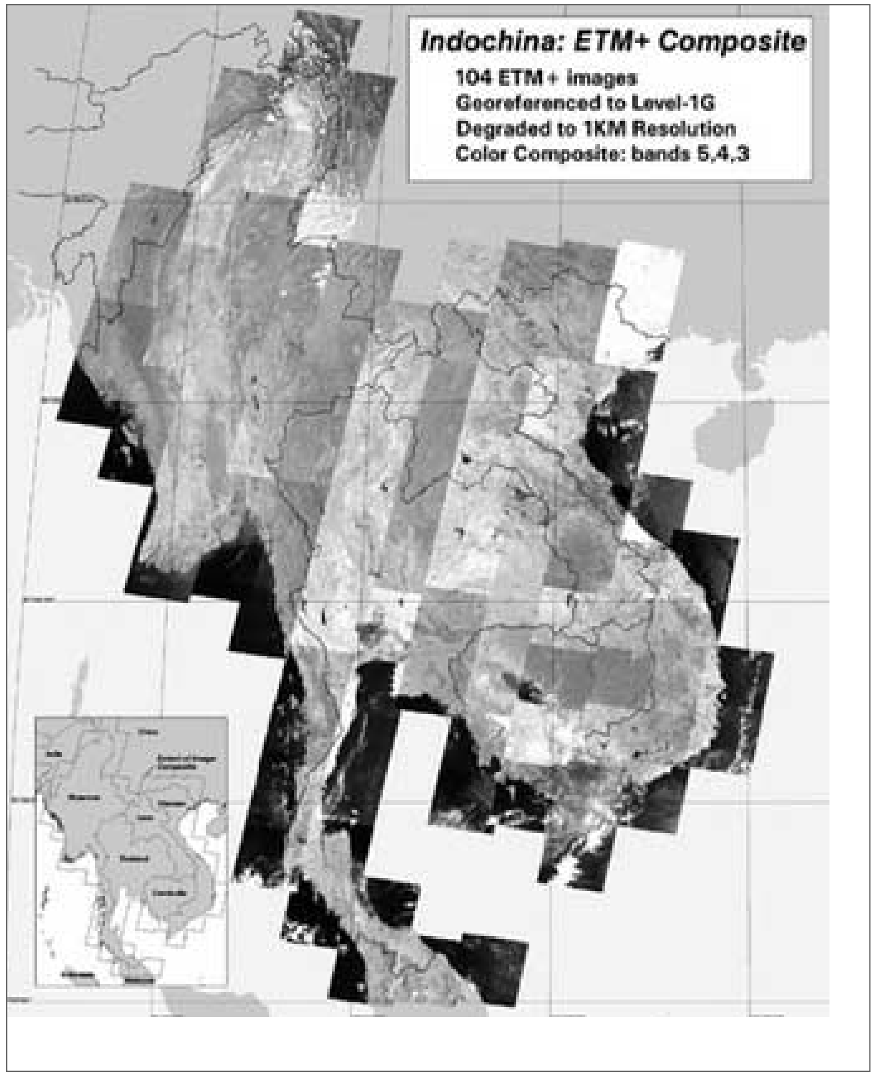
# Making a Forest Map of Southeast Asia


Natural resource managers have new tools for their work with satellite imagery. About 100 Landsat scenes appear in the image of Southeast Asia (above right). From this mosaic of images, scientists composed the forest cover map (left). With satellite remote sensing and Geographic Information Systems (GIS) technology, scientists can accurately measure the rate of change and extent of tropical deforestation. With these data, they can determine the net release from the forest to the atmosphere of important trace gases such as carbon dioxide, which impact climate and other aspects of the Earth system.

*Images credit: Tropical Rain Forest Information Center, Basic Science and Remote Sensing Initiative at Michigan State University (A member of the NASA Federation of Earth Science Information Partners)*

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# *For the Classroom…*

Introduce major concepts of "Land – Our Changing Earth" by dividing the class into small teams to research several of the questions below. Students can research their answers using the poster and the Internet links found at the URL below. Students can prepare presentations to cooperatively instruct other teams using pre-established teacher criteria.

- How does the Earth's land surface change through time?
- What are some of the ways people change the Earth's land surface?
- Where is the destruction of forests taking place most rapidly, and why there?
- How might land cover and land use changes affect wildlife and plants?
- What are some of the ways that events and processes taking place on the land surface affect the atmosphere?
- How can people use satellite observations to prevent and fight fires?
- What do Earth-observing satellites show us that can help us decide where and how to live?
- What can satellite images tell us about natural hazards such as volcanoes, fires, floods and drought?

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